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QUANTIFICATION OF INTRAMUSCULAR FAT IN THE *LONGISSIMUS DORSI* OF FED BEEF CATTLE

L. Garcia*, T.E. Lawrence, T.H. Montgomery, D. Parker, & M. Brown

Department of Agriculture, West Texas A&M University

Key Words: *longissimus dorsi*, Intramuscular fat, Beef

Introduction

Approximately 26% of the U.S. fed cattle population is fed and harvested in the Texas Panhandle annually (SPS, 2000). Beef carcasses are assessed a dollar value per carcass weight based on a combination of quality grade (marbling score of the loin muscle and estimated physiological maturity) and yield grade (estimation of fat to muscle ratio). These estimates are determined by evaluating the exposed *longissimus dorsi* muscle between the 12^{th} and 13^{th} ribs.

The value assigned to a beef carcass greatly depends on the amount and distribution of the marbling observed at a single point, by a USDA grader. However, determining marbling at one given point may not represent the entire *longissimus dorsi* muscle. Previous research, (Blumer et al. 1962; Cross et al., 1975) suggest that marbling varies throughout the *longissimus* muscle.

Objectives

To illustrate the variation of intramuscular fat throughout the l*ongissimus dorsi* muscle using subjective visual evaluation and crude fat analysis.

To develop predictive equations to estimate percent crude fat in beef *longissimus dorsi* muscle from subjective marbling.

Methodology

Beef *longissimus dorsi* muscles (n = 40) were selected at a commercial beef processing facility in the Texas Panhandle. Two trained personnel subjectively evaluated marbling at the 12th/13th rib interface. *Longissimus dorsi* muscles were selected based on specific criteria of the following: 1) quality grades (USDA Select (n=10); USDA Low Choice (n=10); USDA High Choice (n=10); and USDA Prime (n=10), 2) external fat ranged from 2.5-3.7 mm, 3) ribeye area ranged from 81.93 cm^2 to 88.38 cm^2 and 4) hot carcass weights ranged from 334 kg to 378 kg. The muscles were transported under refrigerated conditions to the West Texas A&M University meat laboratory and stored overnight at 1.6°C.

Fabrication

Seventy-two hours after harvest, muscles were fabricated into 3.175 cm transverse slices. After slicing, steaks were allowed to bloom for 30 min. (forming a bright cherry red color) to allow oxygenation of myoglobin.

Subjective evaluations

Two trained panelists subjectively evaluated visual marbling scores on each sliced steak using USDA marbling cards as a reference. Individual partitions were provided to separate individual slices during the evaluation process. The posterior surface of the wholesale rib slices and anterior surface of the wholesale loin slices were used for evaluation under incandescent lighting (1,304 lux).

Crude fat analysis

Transverse slices (0.635 cm thick) were removed from the evaluated side of each slice. External fat and connective tissue were removed and the muscle tissue was cut into 2.5 cm X 2.5 cm cubes. Cubes were kept in a –70^{o}C freezer (Revco Upright Elite) for at least 24 h. Once frozen, the muscle was pulverized using a Waring blender. Samples from each carcass were analyzed for percentage of fat by microwave oven and nuclear magnetic resonance analysis following AOAC (PVM – 1:2003) procedures. Briefly, two glass fiber square sample pads were used to spread a 3-5 g meat sample. Each meat sample was evenly spread across the pad then covered using another pad sandwiching the sample. Meat samples were dried by a moisture/solid analyzer microwave chamber revealing percent moisture after dried to a constant weight. Pads were removed and rolled in a Trac film and compressed in a plastic sleeve and placed in a NMR (Nuclear Magnetic Resonance) chamber for analysis.

Statistical Analysis

A one-way treatment structure was used in a complete block experimental design structure. Carcass was the blocking factor, anatomical position within the loin was the treatment, and a slice of loin was the experimental unit. Data were analyzed using the MIXED procedure of SAS (SAS Institute; Cary, NC). The model included the fixed effect of position within the *longissimus* muscle and the random effect of carcass. Treatment means were generated using the LSMEANS (also known as adjusted means) option and separated when significant ($P<.05$) using the PDIFF option.

Crude fat and visual intramuscular fat data were analyzed using the Proc REG procedure of SAS (SAS Institute, Cary, NC) to develop a linear regression model to predict crude fat.

Results & Discussion

Visual marbling score evaluations

Visual evaluations revealed that significant differences ($P < .05$) of intramuscular fat were detected among anatomical positions throughout the *longissimus dorsi* muscle for all USDA quality grades except USDA Select. USDA Prime marbling scores (Figure 1) illustrate a slight tendency for marbling scores to increase toward the posterior *longissimus* region. Box plots (Figure 3) for USDA Premium Choice marbling scores illustrate a tendency for marbling to decrease at extremities as compared to the $12^{th}/13^{th}$ rib interface. USDA Low Choice (Figure 3) and USDA Select (Figure 7) show no trend, indicating somewhat homogenous marbling scores throughout the *longissimus dorsi* for lower quality grades. In agreement with Blumer et al. (1962), Cook et al. (1964) and Cross et al. (1975), the current data revealed that marbling is randomly deposited throughout the *longissimus* muscle and varied among anatomical position. Furthermore, variability of marbling score increased as quality grade increased.

Crude fat determination

Crude fat analysis revealed that significant differences ($P < .05$) of crude fat percentages were detected among anatomical positions for all USDA quality grades. Box plots for all quality grades illustrate high variability for crude fat throughout the *longissimus dorsi* muscle, suggesting that marbling is independent among anatomical positions.

Regression equation

The regression equation developed to predict the percentage of crude fat from a known marbling score is as follows: crude fat = (- 0.58) + 0.17 * marbling score (R^2 = 0.55). Unaccounted variability may be due to experimental errors from laboratory procedures, handling and processing of samples.

Conclusions

This study investigated the variation of intramuscular fat within the *longissimus dorsi* muscle. Visual (subjective) evaluations suggested that estimating marbling at one given point ($12^{th}/13^{th}$ rib interface) was representative of the marbling average of the entire loin. Crude fat values suggested that intramuscular fat increases from the midpoint of the loin to the extremities.

A predictive equation can be utilized to determine a crude fat percentage based on visual marbling evaluation. Coefficient of determination (R^2 = .55) indicate that just over 50% of the variation in crude fat is accounted for by visual marbling. A predictive equation of crude fat percentage can be utilized to communicate on a common scale with everyday consumers. Branded beef programs or retailers could purchase and sell products based on a fat percentage basis rather than a quality grade basis. Additionally, crude fat

percentage could be used to determine if a beef product were eligible to be sold according to the American Heart Association guidelines.

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Tables and Figures

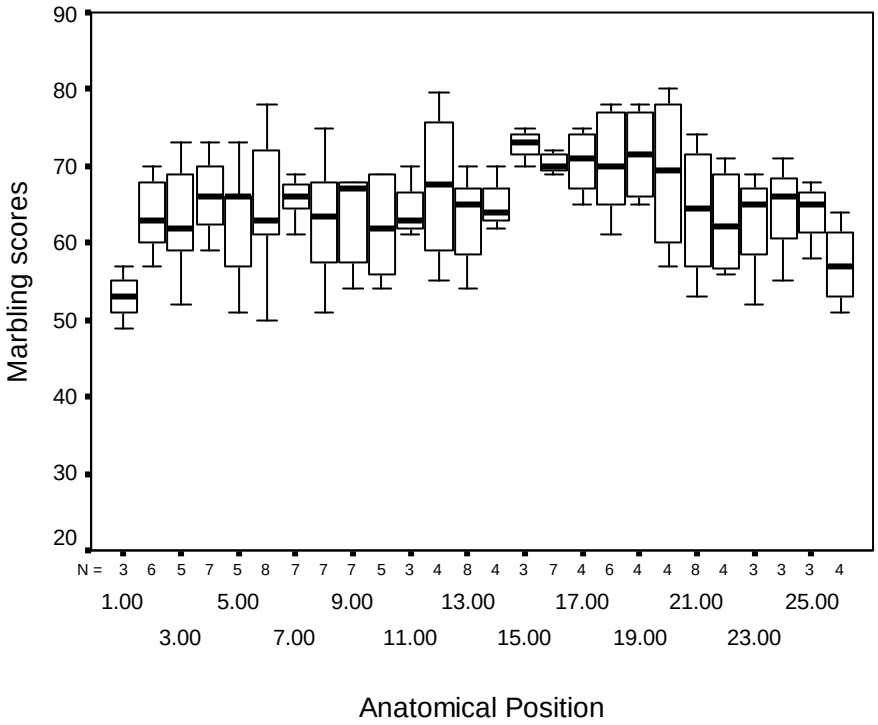
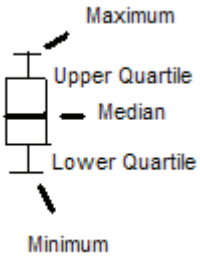


Figure 1. Box plots of visual marbling scores among anatomical positions for USDA Prime *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Marbling scores: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}, 60 = Moderate^{00}, 70 = Slightly Abundant.
Anatomical position 1 = most anterior….26 = most posterior



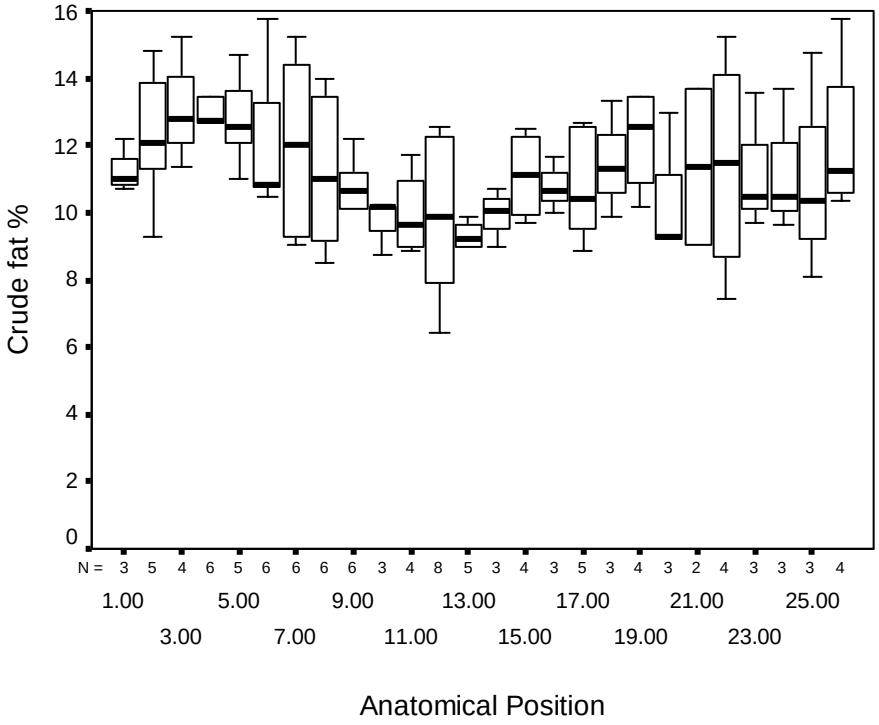
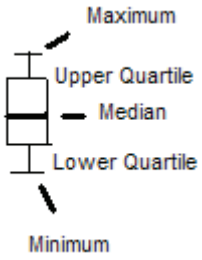


Figure 2. Box plots of crude fat percentage among anatomical positions for USDA Prime *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Anatomical position 1 = most anterior….26 = most posterior



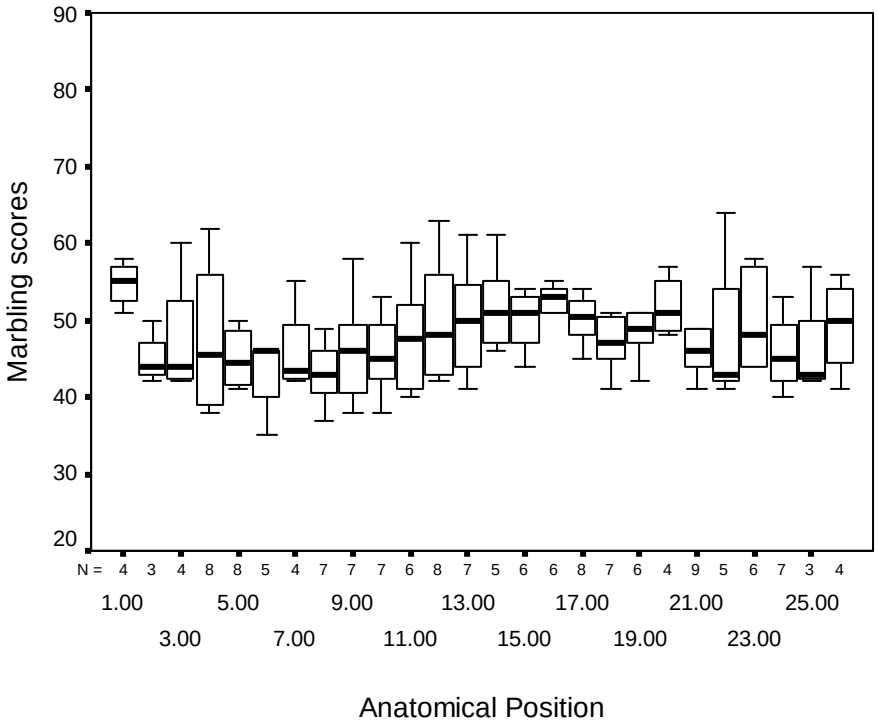
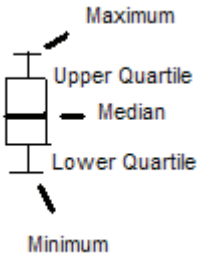


Figure 3. Box plots of visual marbling scores among anatomical positions for USDA Premium Choice *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Marbling scores: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}, 60 = Moderate^{00}, 70 = SlightlyAbundant.
Anatomical position 1 = most anterior….26 = most posterior



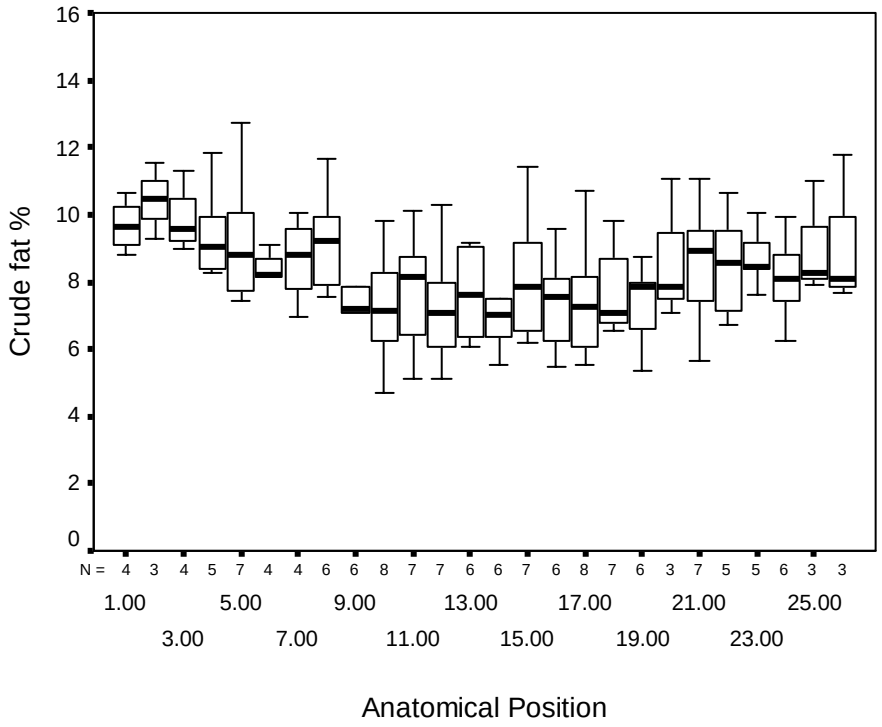
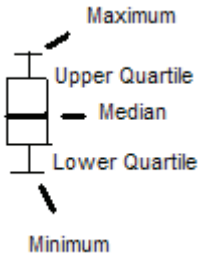


Figure 4. Box plots of crude fat percentage among anatomical positions for USDA Premium Choice *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Anatomical position 1 = most anterior….26 = most posterior



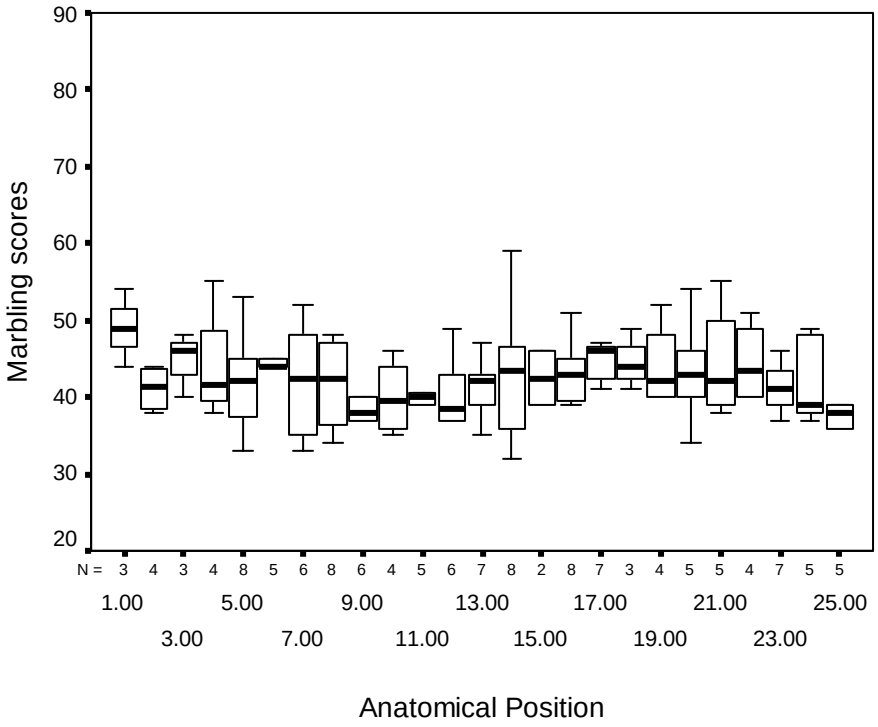
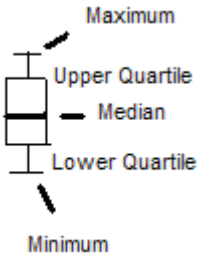


Figure 5. Box plots of visual marbling scores among anatomical positions for USDA Low Choice l*ongissimus dorsi* muscles.

N = number of total slices within each anatomical position
Marbling scores: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}, 60 = Moderate, 70 = Slightly Abundant.
Anatomical position 1 = most anterior….25 = most posterior



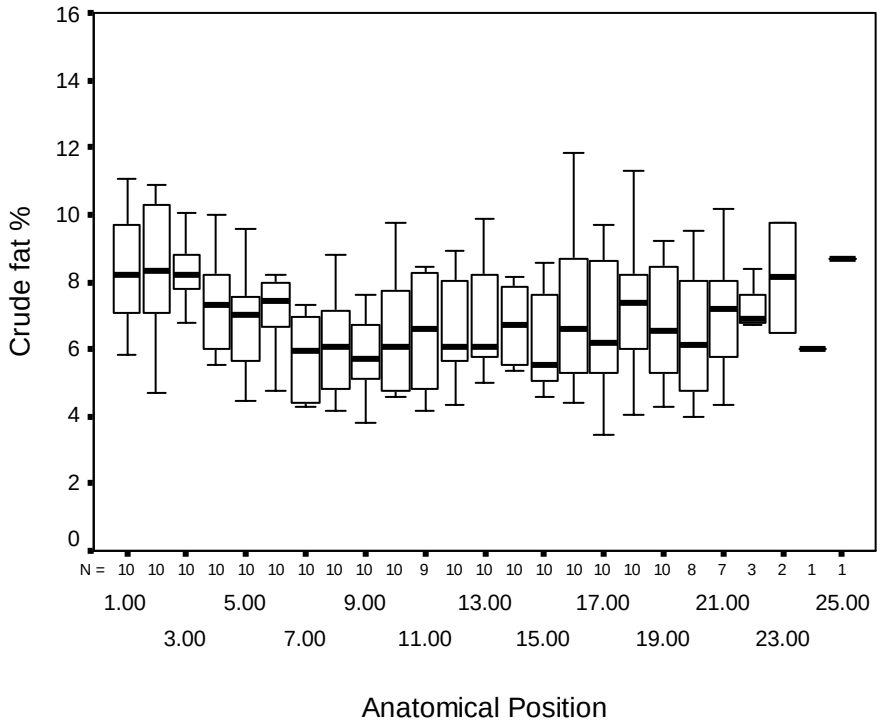
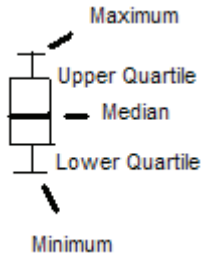


Figure 6. Box plots of crude fat percentage among anatomical positions for USDA Low Choice *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Anatomical position 1 = most anterior….25 = most posterior



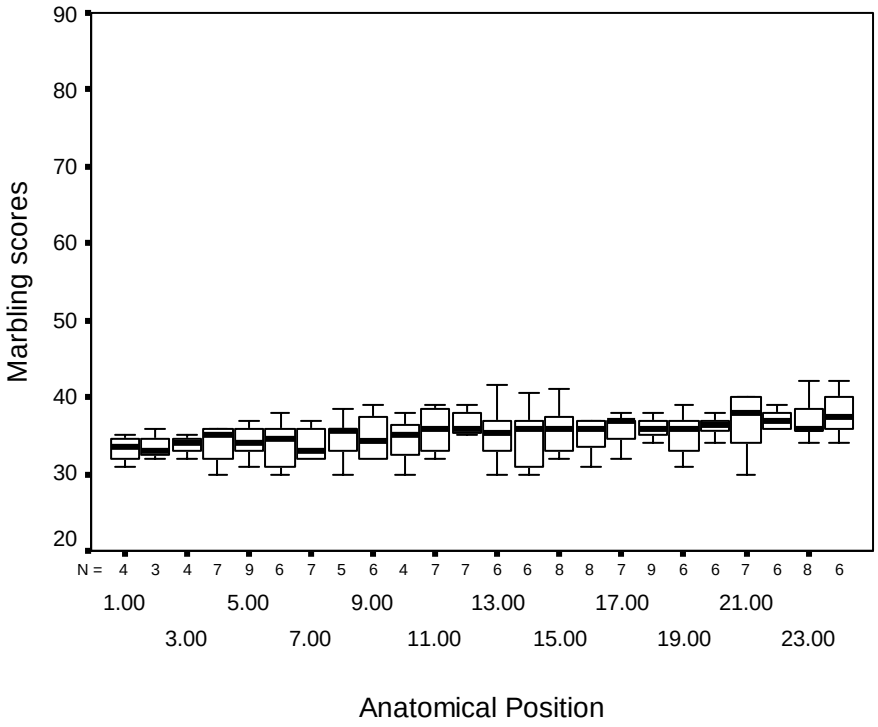
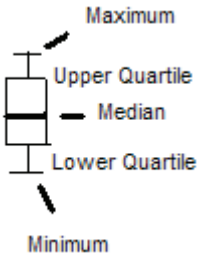


Figure 7. Box plots of visual marbling scores among anatomical positions for USDA Select *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Marbling scores: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}, 60 = Moderate^{00}, 70 = Slightly Abundant.
Anatomical position 1 = most anterior….24 = most posterior



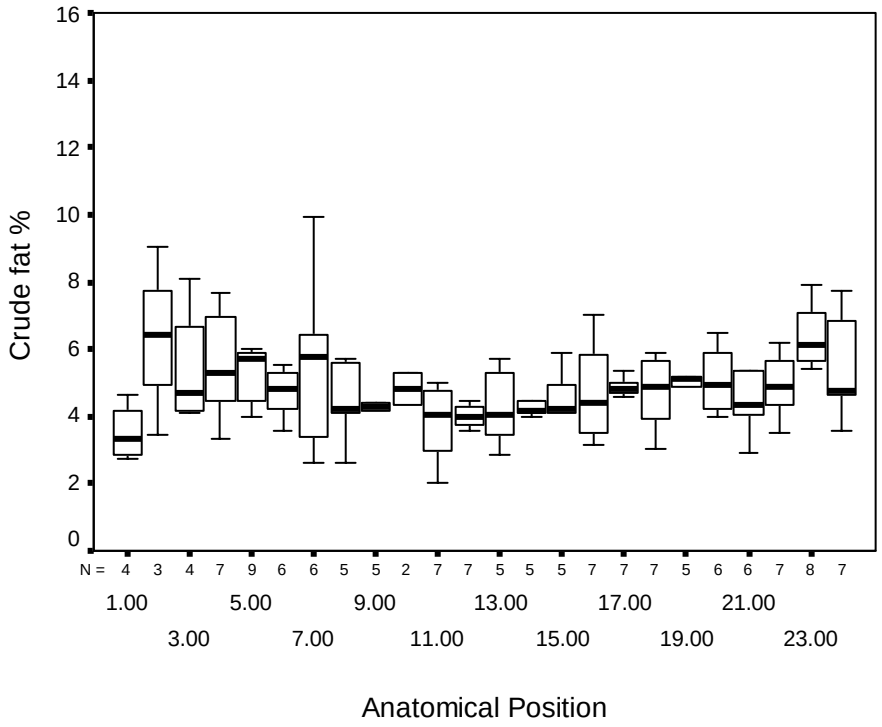
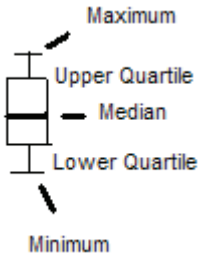


Figure 3.14. Box plots of crude fat percentage among anatomical positions for USDA Select *longissimus dorsi* muscles.

N = number of total slices within each anatomical position
Anatomical position 1 = most anterior….24 = most posterior



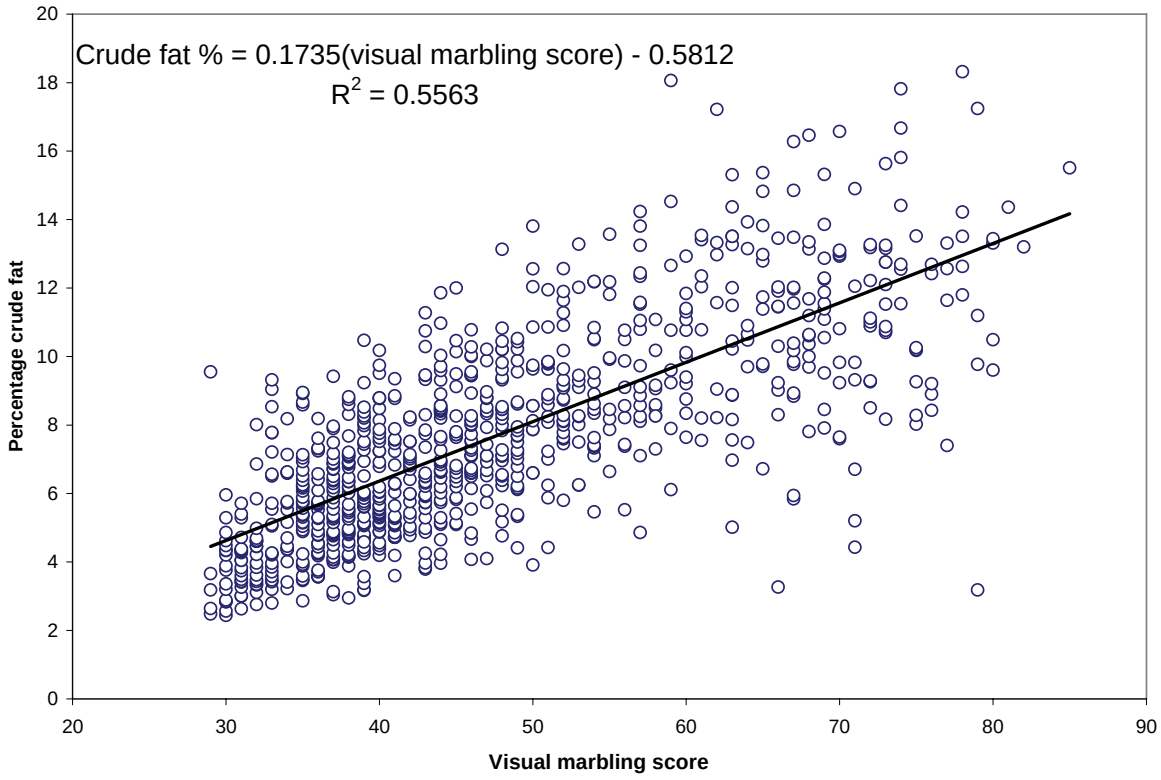


Figure 9. The relationship between visual marbling scores and crude fat percentage of beef *longissimus dorsi* muscles.

Marbling scores: 30 = Slight[00], 40 = Small[00], 50 = Modest[00], 60 = Moderate[00], 70 = Slightly Abundant, 80 = Moderately Abundant